Energy Policy 210 (2026) 115069

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Don't charge while you heat! The social potential for flexibility and coordination of energy-intensive technologies in single-family houses

Carolina Hiller[a,*], Hanna Björner Brauer[a,b], Magdalena Kania-Lundholm[c], Erik Lundberg[c], Therese Olsson[d]

[a] RISE Research Institutes of Sweden, Division Built Environment, 400 20, Göteborg, Sweden
[b] University West, Department of Social and Behavioural Studies, 461 86, Trollhättan, Sweden
[c] Dalarna University, School of Culture and Society, 791 88, Falun, Sweden
[d] Dalarna University, School of Information and Engineering, 791 88, Falun, Sweden

ARTICLE INFO

Keywords:
Energy flexibility
Coordinated flexibility
Social practices
Heat pumps
Electric vehicles
Power peaks

ABSTRACT

This study explores the social potential for flexibility and coordination of energy-intensive technologies, specifically electric vehicles and heat pumps – an increasingly common combination in Swedish single-family homes with diverse needs and motivations. As electrification rises and power peaks grow more concerning, the research examines flexibility in everyday EV charging and heating practices, focusing on enabling and hindering conditions. Drawing on 21 household interviews and social practice theory, the study found that flexibility potential was influenced by temporal, geographical, and material conditions, along with values, expectations, and experiences. Alternative charging strategies and frugal heating practices demonstrated flexibility, especially among households valuing environmental care. Foreseeability supported flexibility, while rigid schedules and high comfort expectations posed challenges. Practices centred around care were important but could reduce flexibility, and unfavourable combinations of geographical and material conditions further constrained it, but instead shaped fragility and awareness. Coordinating EV charging with heat pump use and adapting to new power tariffs proved complex. The study highlights the importance of understanding the social dimensions of energy flexibility and offers insights for policymakers and energy providers to support households in managing and coordinating practices related to multiple energy-intensive technologies in response to price signals and power demands.

1. Introduction

Electrifying the car fleet is widely viewed in energy policies as essential for achieving a low-carbon society (Government Offices of Sweden, 2022; IEA, 2023b). The rise of electric vehicles (EVs), which are usually charged at home (Vanhaverbeke et al., 2024), is changing the traditional division of energy use in transport and housing. This shift increases household electricity consumption and risks power peaks in local grids if many power-consuming appliances are used at once in homes. This is particularly true for electrically heated houses with heat pumps (HPs), common in countries like Sweden, the context of this study. Globally, heat pumps account for around 10 % of the heating demand in buildings, with significant variation across countries; the U.S. and China lead in deployment (IEA, 2023a). Heat pumps are also widely recognised as a key technology for decarbonisation.

Growing electricity demand and an ageing grid lead to insufficient capacity during peak times (EC, 2023; Ei, 2020). Mandatory in Sweden from 2027 (Ei, 2022), financial instruments like power-based tariffs, alongside variable hourly pricing, are being advocated by policymakers and the electricity industry internationally (Eurelectric, 2021) as tools to reduce peak electricity demand and encourage off-peak consumption. These price signals aim to inform households that both the *amount* and *timing* of electricity use affect their bills. To keep costs down, households, especially those with hourly contracts, need to be flexible when they carry out activities that require electricity.

The "energy crisis" of winter 2022/2023, which saw significant fluctuations and rises in electricity prices, highlighted the importance of household electricity management (Björner Brauer et al., 2024; Gram-Hanssen et al., 2024). Yet many households are still learning about their electricity use, becoming more flexible, and managing their use of large

* Corresponding author. RISE Research Institutes of Sweden, Division Built Environment, Box 14092, 400 20, Göteborg, Sweden.
E-mail addresses: carolina.hiller@ri.se (C. Hiller), hanna.bjorner.brauer@ri.se (H. Björner Brauer), mkd@du.se (M. Kania-Lundholm), elb@du.se (E. Lundberg), tos@du.se (T. Olsson).

https://doi.org/10.1016/j.enpol.2026.115069
Received 11 June 2025; Received in revised form 22 December 2025; Accepted 4 January 2026
Available online 16 January 2026

appliances in response to power peaks and price signals (El Gohary et al., 2022; Hansen and Aagaard, 2025; Pelka et al., 2024; Pitkänen and Skjølsvold, 2024). In light of increasing electrification in homes, studies are thus needed, from a social perspective, to enhance the understanding of households' practices and handling of major electricity consumers, like EVs and HPs, which have the potential for great flexibility but may require coordinated usage (Muttaqee et al., 2024; Torriti and Ramírez-Mendiola, 2022). Continuously and empirically revisiting topics of flexibility and households' responses to price signals is essential as energy-intensive technologies are increasingly adopted by households with diverse conditions, needs, and motivations (Pelka et al., 2024). EVs and HPs are an excellent example of two energy-intensive technologies, as they are an increasingly common combination in Swedish homes and address essential needs for heating and mobility in everyday life.

We will therefore focus on household energy practices, flexibility, and the everyday use of electric vehicle charging and heat pumps. The analysis will conceptualise energy flexibility through social practices, providing a theoretical basis for understanding how practices are interconnected in daily life and the potential for shifting and coordinating these practices. In this way, the study aims to generate valuable insights for policymakers and energy sector stakeholders to more effectively address household flexibility, the coordination of energy-intensive technologies, and responses to price signals.

1.1. Flexibility and household energy practices

Extensive research worldwide has examined the technical and economic potential of energy flexibility, including from the residential sector, and its implications for electricity grids (Li et al., 2022). Key topics include enabling and constraining factors for distributed energy resources (e.g., Gorenstein Dedecca et al., 2025; Shen et al., 2021), load and flexibility forecasting models (e.g., Papias et al., 2025; Wu et al., 2025), demand-response strategies (e.g., Rustamovich Esanov and Gyoon Lim, 2025), technical and market limitations (e.g., Stange et al., 2025), and economic benefits (e.g., Sperber et al., 2025). Previous studies emphasise that household contributions to energy flexibility also require a social perspective (Henriksen et al., 2025; Lo Piano and Smith, 2022). Building on this perspective, the present study adopts a qualitative approach, cf. Bryman (2016), to explore household conditions, social contexts, and sense-making that shape the social potential for energy flexibility. By providing descriptions and deeper insights into how households engage in practices related to electric vehicles and heat pumps, this approach complements quantitative research (e.g., the references mentioned above) and informs the design of more targeted and nuanced policies to promote household energy flexibility.

The following sections elaborate on flexibility and household energy practices.

1.1.1. Being flexible with charging and heating

Conditions for households' flexibility in EV charging and driving are still under-researched (Chen et al., 2024b). Studies suggest that monetary benefits and perceived cost savings significantly influence households' willingness to be flexible (Henriksen et al., 2021; Hofmann and Lindberg, 2024; Marxen et al., 2023). Homeowners and high-income households are more likely to be flexible with charging due to greater resources and fewer time constraints (Chen et al., 2024b; Marxen et al., 2023). Environmental concerns and technological interest also promote energy flexibility (Chen et al., 2024b; Henriksen et al., 2021; Kaviani et al., 2025).

Unlike EV charging, houses' heating systems are often overlooked in daily life (Gram-Hanssen et al., 2024). However, thermal comfort is a priority for households, and willingness to be flexible, such as price-controlling heat pumps, depends on the impact on comfort (Nalini Ramakrishna et al., 2024; Nambiar et al., 2025; Parrish et al., 2020). Importantly, perceptions and expectations of thermal comfort vary, which may explain why some people notice even small temperature reductions due to flexible control (Vilaseca et al., 2022), while others do not (Björner Brauer et al., 2023). Expectations of thermal comfort, and responses to reduced indoor temperatures, are shaped by past experiences (Luo et al., 2018), knowledge, and values related to heating practices (Björner Brauer et al., 2023; Gram-Hanssen et al., 2024; Vilaseca et al., 2022), such as frugality, environmental concern, or technical interest (Gram-Hanssen et al., 2024; Nilsson and Bartusch, 2024). High costs and potential savings also motivate households to adjust temperature settings and adopt flexible heating control (Björner Brauer et al., 2024; Gram-Hanssen et al., 2024; Nilsson and Bartusch, 2024).

Domestic hot water (DHW) from heat pumps is typically used at the house's water taps, primarily for personal hygiene, and is, together with other practices, integrated into the rhythm of daily life (Cahill et al., 2024). DHW usage often peaks in the morning and evening for baths and showers (do Carmo and Christensen, 2016; Gram-Hanssen et al., 2020). These practices are not easily adjustable (Zapieo et al., 2024) and are associated with values like cleanliness, comfort, freshness, relaxation, and peace (Cahill et al., 2024). However, crises, as well as tariff designs, can affect water practices and shower routines (Björner Brauer et al., 2024; Cahill et al., 2022; Onuki and Otaki, 2025).

Most energy flexibility studies focus on specific technologies or general flexibility. Given the complexity of following multiple price signals (Stikvoort et al., 2024) and grid capacity uncertainty in countries like Sweden, it is essential to investigate the flexibility of different appliances together to explore if and how practices around them can be *adjusted* and *coordinated* to avoid power peaks and high electricity costs. Additionally, there is a shortage of qualitative studies on households' practices and flexibility with EV charging, which is crucial as EV adoption is expected to rise significantly.

1.1.2. Social practice theory

Social practice theory, developed by Schatzki (1996), Reckwitz (2002), and Shove et al. (2012), identifies patterns of human activity and their evolution. It maps everyday life by focusing on capabilities, infrastructures, and ideas that enable, reinforce and change practices (Gram-Hanssen, 2010; Shove et al., 2012). This theory explains residential electricity use by showing how demand arises from established practices and routines (Gram-Hanssen, 2010; Strengers, 2013b), often arranged by society's structural organisation and reinforced by societal norms (Shove, 2003; Shove and Walker, 2014). For example, commuting by car is shaped by infrastructure, work schedules, and social norms. Effective changes in electricity use must therefore consider how practices are influenced by several aspects, including infrastructures, technologies, competencies, societal organisation, and human aspirations (Blue et al., 2020; Shove, 2003; Strengers and Maller, 2012).

Practice theorists vary in their analytical breakdown of practices. We adopt Shove et al.'s model (Shove et al., 2012), which defines practices through three elements: meanings, materials, and competencies. Meanings encompass norms, goals, aspirations, and motivations; materials include technology, infrastructure, and equipment; competencies cover individuals' knowledge, skills, and experience. Shove et al.'s model suits our paper well, as it aligns with our material focus on two impactful technologies: EVs and HPs.

1.1.3. Social practices and energy flexibility

From a practice perspective, achieving household energy flexibility is not just about financial or informational incentives. It involves examining how households' lives are structured and how energy is used. Everyday practices are often arranged according to institutional timing like work and school hours (Blue et al., 2020). Practices are interconnected and occur in sequences, such as cooking dinner, feeding, and putting children to bed in a specific order (Blue et al., 2020; Nicholls and Strengers, 2015). In addition, practices shared by several individuals in a household are tied together both by their shared routines, such as having dinner together, but also by shared material elements such as washing machines or water boilers (Blue et al., 2020). These configurations create a rhythm in everyday life, making it challenging to change or be flexible in established practices, such as reducing electricity use to cut costs (Nicholls and Strengers, 2015). While energy flexibility is possible, incentivising it affects daily lives, and financial incentives alone, without understanding households' needs, drivers, knowledge, and living conditions, may result in low uptake. To enhance the understanding of the social potential for flexibility in practices linked to HPs and EVs, we use the elements of social practice theory as analytical starting points. By examining aspects related to the meanings, materials, and competencies of households' heating and charging practices, we explore how these practices are temporally and practically organised in people's daily lives, how possible shifting, coordination and prioritisation between these practices could be achieved, and what conditions enable this.

2. Objective

The objective is to examine and understand the social potential for flexibility and coordination of everyday practices linked to the electricity use of heat pumps and electric car charging in single-family homes.

To achieve this, we interview Swedish households experienced with practices related to these two energy-intensive technologies to obtain depth in empirical data. This directs our sample to households that have at least one electric vehicle and live in single-family detached houses heated with heat pumps. Through the lens of social practice theory, the study explores conditions that enable and hinder household energy flexibility in these practices. Additionally, it introduces ideas about "coordinated flexibility", where the flexibility of electric vehicle charging, heating, and hot water activities is considered jointly to avoid power peaks and high costs. We call this coordinated flexibility because it emphasises managing simultaneously, and prioritising between, multiple energy-intensive practices. It also ensures that time-shifted practices do not create new power peaks that could undermine the intended purpose of tariffs, namely to alleviate grid capacity constraints as envisioned by policymakers and the energy sector.

3. Methods

This section presents Sweden as an empirical context, focusing on heat pump and electric car distribution, and describes the empirical data collection and analysis.

3.1. Sweden – the long (narrow) heat pump country

Sweden, a long country in the northern latitudes with diverse weather and climate conditions, experiences variations in temperature, sunlight, and precipitation across its four distinct seasons. These factors impact battery range, heating, cooling, insulation needs, and other energy-related parameters. There are considerable regional differences in electricity prices, with higher prices generally in the south and lower prices in the north, due to most power production being in the north while a large share of the population lives in the south.

Over 40 % of Swedish households live in single-family houses, with more than half heated by electricity, including heat pumps, which also commonly produce domestic hot water (Statistics Sweden, 2024; Swedish Energy Agency, 2024). Promoted by government initiatives, heat pump technology reached market maturity for residential heating by the mid-1990s (Ambrose et al., 2023) and is now standard in newly built electrically heated homes. Swedish houses typically feature high levels of insulation and airtightness, although older buildings show some variation. Combined with hydronic systems and often floor heating, these characteristics provide substantial thermal buffering, enabling heat pumps to operate flexibly without significant changes in indoor temperature (Chen et al., 2024a; Lindahl et al., 2023). Their centralised control further makes these systems strong candidates for coordinated flexibility and control.

Electric cars represented just over 7 % of Sweden's total car fleet in 2024 (Transport Analysis, 2025a). However, EV purchases are rapidly increasing, with newly registered electric cars tripling between 2020 and 2024 (Transport Analysis, 2025b). EVs are predicted to comprise 50 % of the car fleet by 2030 (Barr and Topel, 2022). The transition has been driven by purchase incentives for electric vehicles (SFS, 2017:1334), favourable leasing options, and periods of high fossil fuel prices. The purchase benefit was abolished when the government deemed EV costs comparable to conventional cars (Ministry of Climate and Enterprise, 2023). Today, only tax deductions for installing charging stations remain (Swedish Tax Agency, n.d.). The distribution of electric cars is however uneven, with higher concentrations near larger cities, where commuting is common, and lower concentrations in rural areas (Statistics Sweden, 2023). This trend mirrors the expansion of charging infrastructure, more prevalent in densely populated southern areas and sparser in northern inland regions (Power Circle, 2025). In 2020, 76 % of rechargeable vehicles (both electric and plug-in hybrids) were registered by buyers living in single-family houses (Transport Analysis, 2023). Given the prevalence of HPs in these homes, the combination of electric cars and heat pumps is common and expected to grow with vehicle fleet electrification. Therefore, our study focused on households living in detached single-family houses. This focus is also justified by these households' individual cost responsibility for heating and electric vehicle charging, in contrast to other Swedish housing forms where such costs are often included in collective rent. This structure provides single-family homeowners with stronger incentives and greater possibilities to manage electricity costs.

3.2. Recruitment of households

We collected empirical data by conducting an interview study with households experienced in using heat pumps and electric car charging. Using the Swedish Transport Agency's public car registry, we accessed 1000 randomised postal addresses of EV owners, excluding those linked to apartments and commercial vehicles. Letters were sent to approximately 800 households, inviting those with both an EV and a HP to participate. 96 households expressed interest by answering a survey of household details, and a selection was made based on specific requirements and criteria.

Requirements:

- Single-family detached house
- HP with a hydronic heating system that also produces DHW and has been in operation for at least one year
- At least one fully electric car, owned or leased for at least one year
- Home charger
- Regular home charging
- Shared electricity subscription for the house and car charging

Criteria for diversity:

- Different types of HPs
- Variations in the number of rechargeable vehicles
- Gender balance, prioritising female respondents as most addresses appeared to belong to male recipients
- Geographical variation (rural vs. urban, different regions of Sweden)
- Variation in household composition (number and ages of household members)
- Variation in household income

Interviews were conducted with 21 households, involving 30 respondents. All adults were encouraged to participate to capture diverse perspectives. The interviews included households from across Sweden

(Figure A.1 in Appendix A), both rural and urban areas, senior citizens, young and middle-aged couples, and families with children of various ages (Figure A.2), living in houses of different construction years (Table A.1). Based on reported income levels (Figure A.3), three households with two adults and incomes between 500,000 and 749,999 SEK were approximately at the national average level in Sweden, which was 345,529 SEK per person per year in 2023[1] (Statistics Sweden, 2025b). The remaining households had higher income levels, reflecting national statistics where higher income correlates positively with owning or leasing an electric car (Transport Analysis, 2024). Regarding electricity contracts, many (15) participating households had hourly rate contracts, charging by the hour according to spot prices per kilowatt hour, providing economic incentives for flexible electricity usage. This type of contract has increased in recent years, but monthly variable rates remain the most common for all electricity customers (households and companies) in Sweden (Statistics Sweden, 2025a).

3.2.1. Reflections on selection of participating households

The selection of households is motivated by their *practical experience* with the relevant technologies. This qualitative study does not seek to generalise its findings to *all* households; instead, it aims to highlight diverse social mechanisms associated with these technologies, challenging the notion of universal solutions for flexibility. From the large pool of applicants, we sought diversity based on the predefined criteria, including geographic spread and rural representation, which is particularly important for transport-related practices.

Because EVs and new pricing models remain relatively novel, early users – often comparatively well-resourced households, as in our study – are more likely to volunteer and engage in these topics. While their challenges will not be smaller for other groups, additional barriers likely exist for households in different dwelling types and socio-economic conditions, such as the affordability of technology investments, the ability to influence energy costs, and energy literacy. In some cases, more collective solutions may also be relevant, which fall outside the scope of this study.

3.3. Semi-structured interviews

The in-depth interviews were conducted from November 2023 to January 2024. Before the interviews, households were asked to write a short "story" about their daily car and transportation use, which was elaborated on during the interview. Due to the nationwide distribution of households, interviews were conducted online via Microsoft Teams. Interviews lasted 45–60 min and were recorded and transcribed with respondents' consent.

At the start of each interview, respondents were informed about the study and its purpose. The first part of the semi-structured interview guide focused on respondents' daily lives and existing practices related to driving, charging, and heating, as well as their experiences and views on indoor climate, energy use, electricity prices, and power tariffs. Respondents were also asked about their transition from fossil-fuel cars to electric cars and their perceptions of their house's heat pump system.

The second part of the interview explored households' past or current experiences of flexibility and potential future practices related to heating and charging. These alternative practices were discussed through hypothetical future scenarios that could arise due to a more strained power grid, where coordinating energy-intensive technologies like electric car charging and heat pumps could help households avoid higher electricity costs. The aim was to encourage households – and challenge them – to look beyond the present and consider how they might prioritise and adjust charging and heating practices if needed. Drawing on past experiences (e.g., energy crises, cold spells, power cuts), they reflected and made sense of possible alternatives and their household's "wiggle room." This represents current potential, though meaning-making evolves over time, and future practices under constraints may differ. The scenarios were designed around the following themes, based on input from technical researchers: a) Flexibility of working hours due to EV charging, b) Not fully charged EV every day, impacting driving amount, c) Charging EV only on planned days, leading to infrequent car use, d) Sufficiently charged EV but with indoor temperature variation of ± 3 °C, e) Indoor temperature variation of ± 1 °C but with limited and unreliable hot water availability, f) Not price sensitive, willing to pay higher electricity costs to avoid compromising on heating and car charging, and g) Price sensitive, adjusting other energy-related practices or implementing energy-efficient measures.

3.4. Analysis of empirical data

The interviews were analysed using thematic analysis, systematically coding data into larger themes (Braun and Clarke, 2006). Themes were identified based on relevance to the research topic rather than quantifiable measures (Vaismoradi et al., 2013). Employing an abductive approach, researchers explored empirical findings guided, but not determined, by theoretical understanding – a middle ground between data-driven and theory-driven methodologies (Thompson, 2022). Initial observations in the interview transcripts related to the study's objective were shared and discussed to synchronise data interpretation and theoretical alignment, enhancing internal reliability and validity (Bryman, 2016). Identified overarching phenomena, similarities, and differences were then used for detailed coding, thematisation, and analysis.

The analytical focus revolved around household energy flexibility and coordination of heating and charging practices, including enabling and hindering conditions. From a social practice theory perspective, flexibility is about the ability to shift – and possibly coordinate – practices. Therefore, we examined how flexibility was 1) affected by elements associated with specific practices, and 2) influenced by the interconnections between households' daily practices. Many notes concerned the timing and scheduling of daily life and how the electric car facilitated it. Guided by how social practices relate to each other, this led to the first major theme: temporal flexibility. Other notes related to how practices and flexibility were influenced by households' technologies and local conditions, forming the theme of material and geographical conditions. Additional notes addressed the values associated with EVs and HPs in daily life and the significance of previous experiences and competence for flexibility potential, constituting the third thematic area.

These three overarching themes are presented next. References to respondents are made using fictitious names.

4. Results and analysis of social potential for energy flexibility and coordination

To begin with, electric vehicles and heat pumps played different roles in respondents' homes and daily lives. EVs represented a deliberate technological advancement, requiring new skills and adjustments in driving and charging practices. Households primarily charged their EVs at home, learning about the car's range under various conditions and how to optimise charging times. The car was a highly valued enabler and convenience for activities, work, school, and family life. Many households had backup vehicles, either fossil-fuel cars or another EV, for longer trips or when the primary EV wasn't sufficiently charged. While car dependency was prevalent, some respondents also utilised cycling or public transport for their transportation needs. In contrast, HPs were quite backgrounded technology, less prominent in daily life, though some technically inclined respondents interacted with their heating and control systems. Indoor temperature and hot water were more noticeable and associated with clear expectations and preferences.

Two tendencies emerged in flexibility with HPs and EVs. First, some

[1] This is the median income for individuals aged 20 and older who were registered residents in Sweden throughout 2023.

households were already flexible and/or frugal with car charging and heating. This was carried out either manually or using smart charging and heating apps. Second, households had margins in their transportation and heating practices, making flexibility possible, with, for instance, enough battery capacity to avoid charging full nightly.

When we analysed the households' situations more closely and how flexibility was integrated into their daily lives, we found that flexibility was influenced by social practice elements and how practices were arranged, constrained, and interconnected. Conditions for flexible heating and charging varied, affecting the ability to engage in further flexibility and possibly also to perform flexibility in a coordinated way. The following sections elaborate on the impact of temporal, material, and geographical conditions, values, experiences, and competencies on flexibility with EVs and HPs.

4.1. Temporal flexibility – scheduling everyday life

Considering potential temporal flexibility, households' acceptance of not being able to leave with the EV at a specific hour in the morning, due to coordination between the HP and EV causing charging delays, was significantly influenced by the sequencing, institutional timing, and scheduling of their daily routines. Families with children and after-school activities particularly emphasised their non-negotiable schedules. Even parents with flexible jobs found it unrealistic to adjust their routines due to the sequence of daily activities. For example, Malin, a parent to triplets, could not stay later at work due to her children's fixed football practice times, highlighting the importance of institutional timing and practice sequencing for flexibility. She felt using flexible work hours to *"help relieve the grid"* was unwarranted. Flexibility in car use also depended on job types. While some, like Fredrik, had flexible work hours, others, like Olle at the municipal rescue service, had fixed hours. Although Olle's colleagues would help if needed, systematic flexibility allowing him to arrive late whenever the grid required was unrealistic.

Households saw the greatest potential for temporal flexibility in changing EV charging patterns to *"little and often"*, as this charging strategy adequately met their daily needs under normal conditions. However, long-distance commuters like Samuel could not rely on such a strategy as he regularly needed daily full charges. Even households with two EVs faced tight battery margins with strict charging strategies. Simon, who sometimes drove 300 km for work, occasionally turned off his smart charging strategy to ensure his car was sufficiently charged.

Some households were willing to be temporally flexible with charging if it was foreseeable, meaning knowing in advance when it is most suitable to use electricity and planning their practices accordingly. For Fredrik's household, this meant planning the amount and time for charging their two EVs based on his and his wife's weekly needs for work trips or other activities. Some households also connected foreseeability to flexibility around heat pump and water practices. Lars reasoned that knowing the best time to shower, he could plan everyday showering accordingly. Others discussed shower flexibility similarly but noted that showering is often part of a sequence of practices such as physical exercise or having a sauna bath, meaning shower flexibility depends on how flexible these practices are.

Upon considering potential temporal flexibility, respondents questioned whether it was reasonable to ask households to significantly adapt their electricity use, affecting daily activities, as society is not designed to support this. For instance, current societal norms around institutional timing do not accommodate households adapting to grid conditions. Christine said,

> *"Society is not really adapted to this yet … and it's not like my employer thinks I'm making a sound choice, 'great that you came an hour late because you had this system for your car that was … ' But at home when it only affects the family that's okay, but it can't be consequences for my job as of now".*

In contrast, retired respondents, with fewer scheduled activities, were more open to rescheduling errands and social plans but drove so little that charging flexibility was rarely needed.

4.2. Material and geographical conditions shaping flexibility, dependencies, and fragility

Arrangements of, and constraints on, energy practices and flexibility were influenced by a combination of material and geographical conditions. Households' locations, from southern to northern Sweden and rural to urban areas, affected the potential for coordinated flexibility. Weather conditions, combined with house characteristics and heat pump sizing, impacted electricity use for heating. Weather also affected EV battery capacity, requiring careful planning for older or smaller EVs. Filip & Karin, living in southern Sweden with mild winters and an older EV, described seasonal variations in charging habits. They charged daily in winter due to quicker battery depletion, while hot summer days required AC use. They termed ideal conditions as *"good EV weather"*, meaning mild weather with minimal AC use and maximum mileage.

Respondents were generally satisfied with their HPs, though some noted limitations. Erik's household had issues with DHW production, and Marcus & Malin needed additional electric radiators in winter. HP's auxiliary heaters were rarely used but helpful in very cold weather. Anna & Sven only discovered the auxiliary heater when their HP's compressor failed, demonstrating its background role. These heaters or additional radiators could challenge flexibility, especially during peak electricity needs like car charging on cold days. Supplementary heat sources like wood stoves also played a role in HP flexibility by maintaining thermal comfort, allowing less use of the HP during cold weather.

Kalle's household, living on a windy island, highlighted the need for adaptations in older, weather-exposed houses. Kalle adjusted the heat pump control to stabilise indoor temperatures and sought a more advanced system with weather forecasts due to rapid weather changes affecting their poorly insulated house. This example illustrated the link between geographical and weather conditions, house properties, and individual technical skills. Households in well-insulated and airtight houses found temporary HP reductions less impactful and unmotivated due to lower overall electricity use.

Distance to work and services, and access to good infrastructure affected the importance of a well-charged car battery, especially when a fossil-fuel car was no longer an option and alternative transport modes were limited. Public transport, cycling, and walking, used daily by some respondents, reduced car dependency and increased charging flexibility. In contrast, Simon, living far out in the countryside with limited public transport and having to walk a few kilometres to catch the only two daily buses, relied on two EVs, making battery range and sufficient charging crucial. Some respondents were materially and geographically tied to a particular place due to work, like Johan, a forest farmer living *"out in the woods"* with insufficient public transport. Others, like Stefan's household, settled strategically near a train station to commute by public transport, reducing EV dependency and charging needs. Thus, location, distances, and transport options, influenced by choices and opportunities, reinforced or reduced car dependency and the need for a charged battery, impacting flexibility potential.

Other interviews highlighted that a combination of limited charging infrastructure and climate factors created fragile situations with reduced EV battery margins. Olle & Christine, in northern Sweden, had short distances to their jobs, allowing them to walk or bike, but had to drive their children to school outside of town due to no bus connection. Olle's part-time forest work also took him further than he dared to go with the EV. Cold winters strongly affected their car's battery range, combined with limited charging infrastructure – the nearest charging station outside of town was 100–150 km away, making it hard to rely solely on their EV and give up their fossil-fuel car. These fragile situations imposed constraints on flexibility and coordination regarding EV charging and HP.

Other combinations of material circumstances also created fragile situations. Houses with multiple energy-intensive technologies, such as two heat pumps and significant home charging, faced challenges. Tore's household, with four adults, had one HP for the main building and another for a smaller building and garage, and also had three EVs. Despite a fixed electricity price, they charged vehicles at night to relieve the grid and avoid overloading the house's electricity fuse. Tore, accustomed to the colder climate in northern Sweden, recently experienced extremely cold spells of −30 °C, impacting the coordination of their energy-intensive technologies. Despite lowering the indoor temperature, the auxiliary heater of the smaller HP was needed, which, combined with other electricity use, strained the main fuse. Consequently, adaptation and flexibility in car charging were necessary, including charging at work and reducing home charging power. Using a wood stove daily also increased heating margins. This example illustrated fragile situations arising from coinciding material and geographical conditions, pushing households to rethink and even act in terms of coordinated flexibility. It also showed how households were already using existing objects, like the fuse, to make sense of how to coordinate electricity use. Others used the fuse similarly, with apps warning them when nearing the fuse limit, allowing them to turn something off or avoid adding more power use. Karl avoided running many appliances while charging the car as a rule, and Bertil & Berit used a load balancer to limit charger power and prevent fuse overloads. Avoiding blowing a fuse by not turning on several large electricity-consuming appliances at once is a straightforward rule that is not novel. However, households' awareness of the necessity to prioritise certain practices over others increases as more items become electrified.

4.3. *Flexibility is influenced by values, expectations, and previous experiences*

Flexibility related to EV and HP practices was shaped by the meanings these practices held in daily life. The interviews revealed economic drivers and values, including care for people and the planet. Previous experiences, competencies, and expectations also influenced households' perceptions of their flexibility.

Households reported that electricity costs influenced their daily practices, sending a clear signal of the importance of considering electricity use and timing. This was particularly evident during the winter of 2022/2023, when higher and fluctuating electricity prices in Sweden provided financial incentives and a reason for learning skills in flexible electricity usage. Households adapted by manually shifting activities like EV charging to cheaper nighttime hours or using smart features to optimise usage. Pensioner Rune said that he was *"old-fashioned"*, preferring to control these things himself, while younger Simon was more comfortable with smart control, using price adaptation for his HP and an app service for EV charging. Costs, age, technical skills, and interest influenced the adoption of smart control, as also seen with Kalle, in his 30s. He used his technical competence and interest in price control to *"push"* his HP when electricity was cheaper. Even Kalle's young children asked about electricity prices before using the hot tub:

"Mum, is it cheap today, can we bathe then?".

While some households engaged in certain control and price adjustments of their heat pump and car charging, coordination was often lacking, and economic priorities varied. Some households were more flexible in reducing heating energy use than car charging during high prices. Various households adjusted their HPs and indoor temperatures, deprioritising values associated with a warm and comfortable house, or meeting these values in other ways, such as using fireplaces. In contrast, driving remained a high priority despite higher prices.

Additionally, adapting to dynamic electricity prices sometimes proved challenging. Fredrik, with two electric cars, found it *"a bit of a gamble"* predicting the lowest price:

"Right now, we actually charge every other day and ignore charging if it's an excessively expensive day, like last winter […] but it usually ends up being that you shoot yourself in the foot because […] if I had charged today, it would have been cheaper and tomorrow it is more expensive."

Price adjustment and control were thus not always simple tasks. In addition, awareness of upcoming power tariffs varied, with limited understanding of their impact, including how the combination of tariffs and electricity prices would affect their adaptation and control. Fredrik speculated about reducing fuse size and finding control systems to avoid running multiple appliances simultaneously. Filip & Karin, with two EVs and living in a grid area with tariffs already in place, usually ignored the tariff due to its complexity. It was *"an additional thing to think about"* while already tracking hourly electricity prices. They also felt punished by the tariff, as Filip noted that one mistake in a month made further coordination pointless since they would be paying a high tariff anyway. However, they compromised between the price signals by establishing a *"house rule"* of not charging both cars on the same night whenever possible.

Increasing complexity was a recurring theme during the interviews. More respondents found that adapting daily life through coordinated flexibility or control of EV charging and HPs to respond to multiple price signals would be challenging. Marcus was sceptical of *"building increasing technical complexity into my house"*, while Tore found it a hassle to adapt usage to economic incentives, requiring monitoring, which had not happened in his household. Erik was reluctant to use smart controls fearing that complicated digital systems could easily malfunction. It was emphasised that increased complexity needed to be balanced against clear economic benefits with flexibility, coordination, and price adaptation.

In addition to economic aspects, cars and heat pumps held other values for households. Respondents expected a warm, comfortable home with consistent temperature, hot water anytime, and a fully charged car for use whenever desired. These conveniences were linked to a comfortable life, independence, and freedom, and were a high priority for some, leaving little room for compromise. For Rune, the car was part of his identity, seeing himself as *"car-borne"* since obtaining his driving licence. Such expectations and deep-rooted values often limited respondents' willingness to even reflect on being flexible with heating, hot water, or charging practices. Erik, for example, was willing to pay higher electricity costs to maintain the convenience of his EV and HP, despite rising costs.

However, there were exceptions, where the energy crisis of 2022/2023 particularly challenged expectations of an unwavering electricity supply, serving as a wake-up call for households. Emilia & Johan, not acknowledging their heating settings before the crisis, realised it was unnecessary to heat their home as much. Households like Simon's, with experience in older, less insulated houses, found it easier to imagine and accept, and even normal for varying indoor temperatures, both between rooms and seasons. Similarly, Stefan's household experienced and adapted to limited hot water supplies in their holiday home, affecting shower frequency and duration for family members. We gathered that these experiences led to knowledge building (competence), and strongly influenced, formed, and even shifted expectations related to heating, hot water, and charging, as well as households' perception of their ability to be flexible.

In our interviews, we observed that caring for others was central to many practices, affecting energy flexibility and adjustments. Care for children, grandchildren, family, and friends was a strong motivator. Parental childcare practices related to EVs included daily needs like school pick-ups and weekend activities, with grandparents sometimes assisting. For example, Bertil and Berit drove their grandchildren in bad weather, especially since the children had previous injuries and were temporarily advised against biking. These caring activities were strongly bound by institutional timing and sequencing, and as they were fixed in the rhythm of everyday life and were important to households, they were difficult to compromise for the sake of energy flexibility. Other activities centred around caring for relationships, like visiting friends, were less time-bound but still important. Roger emphasised that visiting friends was a priority over adjusting for the electricity system. Caring for family also influenced how households assessed battery margin needs, as Michael and Stefan wanted to ensure access to the hospital at any time before any flexible charging system. Caring for friends and family also affected heating practices; for example, Simon paused the price-adaptation function on his heat pump before Christmas to make it warm and comfortable when family and friends were visiting.

Respondents also cared for the planet. Switching from a fossil-fuel car to an EV was strongly linked to a concern for the planet and a desire to reduce carbon emissions. Households with two cars prioritised using the EV for financial and environmental reasons. Michael & Evelina declared *"climate anxiety"* as their motivation for buying an EV. However, many respondents were unclear on how flexibility could aid the energy transition and mitigate the climate crisis. They emphasised the need to understand the purpose of flexibility and coordination beyond cost reduction, especially if such flexibility becomes more invasive, affecting routines and everyday lives. Nevertheless, parents like Amanda, and Christine & Olle, with full-time jobs and busy lifestyles, saw the meaning and link between environmental care and HP flexibility and comfort levels. Amanda said,

> *"I think that you go around and complain about the environment and the world and everything like that. But you're not prepared to make any compromises or sacrifices because of it. I think like this. It's about using the resources we have carefully, and the power grid we have. It is the way it is, and there are some basic necessities we need, but we don't need 25°C indoors and I don't need to shower for 10 minutes in superhot water every day. That's nothing I need for survival"*.

5. Discussion

This study investigated the social potential for Swedish households' energy flexibility and coordination of practices with EVs and HPs. Results revealed flexibility potential in practices associated with both technologies, depending on specific conditions. Some households already utilised this potential, while others did not. The conditions were linked to practice elements that were both shared and varied across the sample and between the two technologies. The main findings are discussed below in relation to previous research.

5.1. Daily routines, experiences, and care explaining flexibility potential

The interviews showed how daily routines, experiences, and care influenced the flexibility potential of households regarding EV charging and HP use. Daily routines and temporal restrictions were often perceived as fixed and not something households were typically willing or capable of compromising for optimised EV charging. This was especially true for households with children, where school, after-school activities, and work must align with the hours set by society's institutions – often referred to as institutional timing, cf. Blue et al. (2020). Our findings confirm that sequences of practices during power peak hours are typically rigid in families, as each activity is bound by the timing of the next (Nicholls and Strengers, 2015). Since neither institutional timing nor society supports households in adjusting their practices for the electricity system, temporal flexibility is often hindered.

Our observations also align with previous research showing that experiences shape comfort expectations and flexibility in heating and hot water practices. Households accustomed to lower or varying indoor temperatures, for example due to less insulated houses or frequent weather changes, tend to find temperature variations more acceptable (Björner Brauer et al., 2023; Luo et al., 2018; Strengers, 2013a). This highlights how comfort and convenience expectations influence practices' flexibility.

Care was identified as a central meaning element in practices related to charging, driving, and heating, including caring for oneself and family members, and the environment and societal welfare. Replacing fossil-fuel cars with EVs reflected such environmental care. This aligns with recent strands of energy research that introduce "ethics of care" to understand household needs and practices (Pink et al., 2024), as well as a possible entry point for changing practices in a more sustainable direction (Gram-Hanssen, 2024; Gram-Hanssen et al., 2025; Kaviani et al., 2025). Our findings support the idea that successful efforts for sustainable and flexible electricity demand must consider how acts of care for oneself, others, shared systems, and the planet are carried out.

The societal value of flexibility and coordination in using HPs and EVs is largely uncertain for households, reflecting the complexity and diversity of local grid conditions and the difficulty households face in understanding the electricity system's development, expectations, and reasons for caring. This demonstrates the importance of, but also the difficulty in increasing energy literacy for flexibility and energy-related practices (Andolfi et al., 2024; Santillán and Cedano, 2023).

5.2. Impact of combined geographical and material conditions

Our interviews with households across Sweden demonstrated how geographical and material conditions intertwined, particularly affecting practices related to EVs and HPs. Unlike laundry, dishes, cooking, and cleaning practices – household practices less influenced by weather and location – factors like outdoor temperature, weather, and distances to services and charging infrastructure significantly impacted the flexibility potential for charging and heating. Geographical factors intersected with material aspects such as house insulation, additional heating sources, the quality and function of heating systems and heat pumps, EV quality, battery range, and the presence of additional cars (e.g., fossil-fuel cars). Unfavourable combinations of these conditions could create fragile situations with tighter margins for households, especially during high electricity demand periods, like cold days combined with long commutes. Fragile situations did not favour households' propensity for flexibility and coordination in using HPs and EV charging. Under such conditions, households needed their cars charged for daily activities, while heat pumps' auxiliary heaters might be in use to meet heating demands.

The way these unfavourable geographical and material conditions coincided for households with electric vehicles and heat pumps not only created fragility in some cases but also heightened awareness of electricity use. In fact, the combination of geo-material conditions, the introduction of a new technology (EV), and variable electricity prices disrupted prevailing practices and re-materialised electricity in everyday life. Previously, electricity use was backgrounded, taken for granted, or unrecognised – as demonstrated in several other studies (Andolfi et al., 2024; Björner Brauer et al., 2024; Hargreavesn et al., 2010; Matschoss et al., 2025). Such disruptions and materialisations are known to open opportunities for change (Laitinen et al., 2025; Spurling, 2021). These geo-material and monetary circumstances signal that electricity is not unlimited and is connected to the local context, countering the perception of year-round energy abundance. Seasonal variations in supply and demand may necessitate frugal, flexible, and conscious charging and heating. To some extent, this reintroduces a "rhythm of infrastructure" (Jalas et al., 2016), where natural resource seasonal and diurnal variations are more visible and experienced by households. This is similar to how water systems are designed and experienced in drought-prone areas, making water either a tangible or intangible resource for households (Maller and Strengers, 2013; Strengers and Maller, 2012). In the case of electricity in Swedish winters, the flexibility of EVs and HPs has a particular way of making electricity more material in everyday life because they are strongly affected by *both* price signals and geo-material circumstances, unlike most other electric appliances.

Seasonal rhythms and weather cycles are recognised as temporal aspects of energy practices (Walker, 2014). However, the combination of distinct geographical and material factors, creating fragility and awareness in households, has not been extensively studied in relation to household energy flexibility, except for a few studies on climate and weather impacts on heating and cooling flexibility (Björner Brauer et al., 2023; Nambiar et al., 2025). This may be due to the limited investigation into experiences of EV and flexibility in EV charging, where these aspects are crucial (Chen et al., 2024b). But as EVs and HPs become a more common combination in homes that may require coordinated usage in response to local grid constraints, we argue that these geo-material aspects will become increasingly relevant.

5.3. *Don't charge while you heat!*

Our study disclosed that expectations and norms around comfort and convenience were not entirely fixed. The energy crisis of 2022/2023, with rising electricity prices and a shared sense of urgency, prompted some households to reassess their heating settings and comfort norms, as well as their charging strategies. This supports studies indicating that price and the promise of cost reduction, combined with a shared sense of concern for the crisis, encourage households to explore energy flexibility and reconsider comfort expectations (Björner Brauer et al., 2024; Gram-Hanssen et al., 2025; Matschoss et al., 2025; Ozaki, 2018).

With upcoming power tariffs in Sweden, financial incentives for households are expanding, raising questions about responding to two price signals to avoid increased electricity costs and coordinating large electricity uses like EV charging and HPs. Our households lacked understanding of power tariffs and their implications, perceiving their energy flexibility or price control as sufficient without valuing temporal coordination and optimisation of multiple electricity uses. However, previous studies highlight that electricity prices and power tariffs can be contradictory signals (Stikvoort et al., 2024). Thus, there was a gap in both the knowledge and meaning elements for our households to engage in a new practice of coordinated flexibility.

Yet some households already practised “don't charge while you heat!”. Faced with challenges related to high simultaneous electricity use, households developed their own practices and rules around coordination, such as coordinating electricity usage to avoid blowing the main fuse. This showed how familiar and understandable artefacts like fuses or power guards could help households make sense of coordination and prioritisation, creating “rules-of-thumb” for not running all major appliances at once, which has been suggested as an easy way for households to change energy-related routines (Stelmach et al., 2020). Considering the complexity of coordinating flexible use of charging and heating in response to multiple price signals, simple ways for households to routinise such coordination may be valuable in the future. Additionally, some households were adopting smart control for their EV charging and HP, which, if developed to handle multiple appliances and price signals simultaneously, could help manage this complexity for those open to it.

Key findings on EV and HP flexibility

Integrating social perspectives into energy flexibility

Flexibility potential: Practices linked to heat pumps and EV charging offer significant flexibility.

Complexity: Coordinated flexibility and adapting to power tariffs are new practice adjustments and are perceived as challenging.

Enablers:

- Little and often EV charging fits daily routines.
- Prior heating experiences shape acceptance of temperature variations.
- Foreseeability supports integration into everyday life.
- Caring for the planet and clear financial and societal benefits motivate engagement.

Barriers:

- Time constraints, especially for EV use.
- Comfort and convenience expectations.
- Competing caring responsibilities.
- Coinciding unfavourable geo-material conditions.

Additional insights:

- Communicating societal benefits is crucial.
- Geo-material conditions raise awareness of electricity use.
- Diverse guidance is needed – from smart tools to simple “rules of thumb.”

Fig. 1. Key findings on households' flexibility potential of EVs and HPs from a social perspective.

6. Conclusions and policy implications

The objective has been to examine and understand the social potential for flexibility and coordination of everyday practices linked to the electricity use of heat pumps and electric car charging in single-family homes. The social potential also comprises the conditions that enable and hinder this flexibility. Key findings are summarised in Fig. 1. The main conclusion is that flexibility potential exists for both technologies. Flexibility for EV charging is more explicit and already in use, while it is more hidden for heating, as heating is taken for granted due to HPs being an integrated technology in homes. Further flexibility in charging is possible through adjustments to “little and often” charging, which fits the daily driving needs and schedules of most households in this study. It is also evident that households' previous experiences with frugal heating influence their flexibility potential, shaping expectations and acceptance of varying indoor temperatures and hot water availability. Beneficial conditions for flexibility in both charging and heating include the need for foreseeability to integrate into daily life, avoiding unexpected constraints. Additionally, flexibility benefits when households' values align with caring for the planet and they see financial and societal gains from their flexibility efforts.

However, several challenges constrain households' flexibility. The first challenge pertains to time management, especially regarding the electric car, which is central to many households' lives. The second challenge involves values and expectations of comfort and convenience, such as a warm home and a fully charged car, making adjustments difficult. The third challenge is about caring responsibilities, where caring for family and friends in convenient ways can compete with flexibility efforts. The fourth challenge is coinciding geo-material conditions. Unfavourable conditions for flexibility occur with cold weather, long distances, and lack of public transport, combined with low standards and capacities of housing, heating systems, and electric vehicles. These conditions vary greatly among households, highlighting their fragility and access to alternative resources, making some reluctant to part with their backup fossil-fuel car. However, it can also heighten awareness of electricity use.

Another conclusion is that households are unaccustomed to considering coordinated flexibility for EV charging and HP use, as it is a new and complex concept for many. They are also unfamiliar with upcoming power tariffs, unlike the varied electricity prices they have adapted to in recent years. However, some households have practical experience navigating high electricity demand and power peaks, using alternative strategies like wood stoves and limited charging to avoid blowing the main fuse. These experiences hint at what may become more common, especially when unfavourable geo-material conditions coincide, and as more energy-intensive technologies are incorporated into future homes, particularly with increased vehicle electrification.

6.1. Policy contributions, limitations and future research

This paper offers a social perspective on energy flexibility and coordination in practices related to electric vehicle charging and heat pump use. We align with others (Henriksen et al., 2025; Lo Piano and Smith, 2022) who emphasise the importance of considering both social and technical aspects for households to contribute to energy flexibility. Key policy contributions, along with limitations and directions for future research, are summarised as follows:

Encouraging alternative practices and communicating benefits: While flexibility is achievable, policymakers and energy sector actors should focus on reducing barriers and promoting factors like alternative charging strategies, sharing experiences of varying indoor temperatures, and clearly communicating the benefits of household flexibility to increase energy flexibility literacy and motivate households.

Accounting for diverse conditions in energy flexibility: Recognising the diverse geo-material conditions of households is crucial as we move towards electrification and increased energy flexibility. Policy and investment decisions should support household flexibility and efficient electricity use, considering these various conditions – particularly in areas with grid and market challenges. These measures can also help maintain the appeal of EV adoption. Additionally, our study's focus on single-family houses with EVs and HPs, as these are good Swedish candidates for coordinated flexibility and control, and on households with good economic status – factors that influence flexibility capacity – limits its applicability to other contexts. As electrification impacts more households, future research and policies should consider flexibility potential, coordination, and price signal effects in diverse conditions, including various dwelling types and socio-economic groups, as well as situations that call for collective solutions. Understanding and accounting for diverse conditions in energy flexibility enables broader household participation in the energy transition and mitigates the risk of leaving many behind.

Preparing households for multiple price signals and coordinated flexibility: Households with the capacity to undertake additional technological investments may view energy storage systems – such as batteries, potentially combined with photovoltaic panels – as promising enablers of flexibility (Muzammal Islam et al., 2024). This warrants attention from policy makers, energy stakeholders, and social science research.

Finally, the gap in awareness and understanding of upcoming power tariffs, including how to respond to them in combination with dynamic electricity prices, needs addressing as nationwide implementation approaches in 2027. Policymakers, electricity suppliers, and grid owners must design financial instruments to help households follow price signals effectively. Guidance should include both smart features and simpler alternatives like “rules-of-thumb” for those less inclined to digitalise their homes. Future studies and policies should evaluate the impact of dual price signals on household energy flexibility on a wider scale and identify effective tools and support for coordinating energy-intensive technologies like EVs and HPs.

CRediT authorship contribution statement

Carolina Hiller: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Hanna Björner Brauer:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation. **Magdalena Kania-Lundholm:** Writing – review & editing, Validation. **Erik Lundberg:** Writing – review & editing, Validation. **Therese Olsson:** Writing – review & editing, Validation.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Copilot in order to check the language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research is part of the project “When the electric car moves in! – The social and technical potential with coordinated control of heat pumps and electric car charging in single-family homes”, funded by the Swedish Energy Agency [grant number P2022–00921]. We would like to thank the interviewed households.

Appendix A

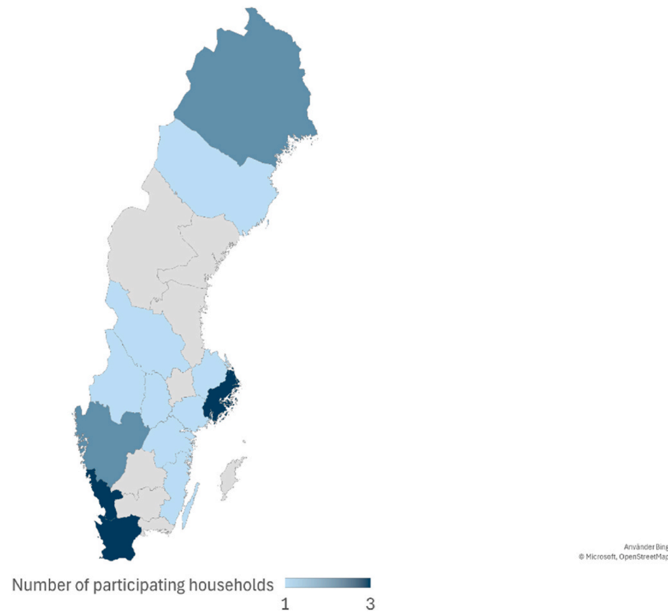

Fig. A.1. Map of Sweden highlighting the counties where the participating households were located.

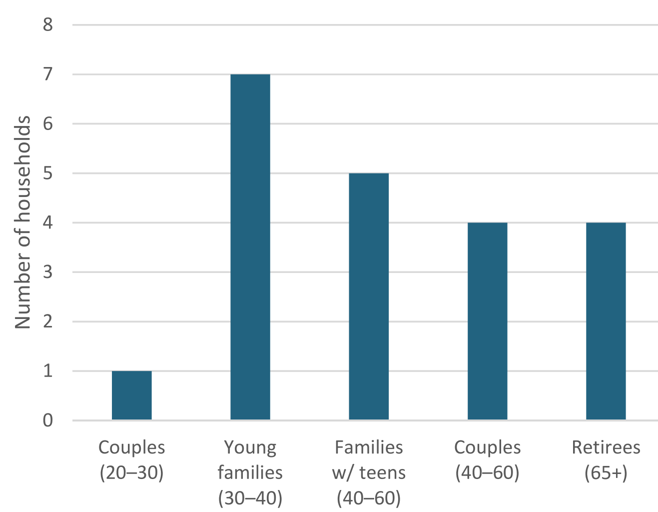

Fig. A.2. Compositions of participating households (couples aged 20–30; families with young children, 1–2 adults aged 30–40; families with teenagers and young adults, 2 adults aged 40–60; couples aged 40–60; retirees, 1–2 adults, at least one person aged 65 or above).

Table A.1
Overview of participating households. Respondents have been given fictitious names.

Respondents (fictitious names)	Household composition	Household's total yearly income, SEK[a] (before tax reduction)	Occupation status	House's year of construction	Heat pump type[b]	Number of cars with different fuels	Electricity contract[c]
Bertil & Berit	Couple: 2 adults in 70's	1,000,000 – 1,249,999	Retired	1974	GSHP	1 electric[d] & 1 fossil	Monthly variable rate
Roger & Veronica	Couple: 2 adults in 60's	750,000–999,999	Retired	1964	GSHP	2 electrics	Hourly rate
Simon	Couple: 2 adults in 20's	750,000–999,999	Employed	1930	GSHP	2 electrics[d]	Hourly rate
Marcus & Malin	Family: 2 adults in 30's & 3 children	1,000,000 – 1,249,999	Employed	1979	ASHP a-w	1 electric & 1 fossil	Hourly rate
Lisa & Kalle	Family: 2 adults in 30's & 2 children	750,000–999,999	Employed & Parental leave	1945	ASHP a-w	1 electric & 1 fossil	Hourly rate
Per & Helen	Couple: 2 adults in 60's/70's	500,000–749,999	Retired	2000	EAHP	1 electric	Hourly rate
Michael & Evelina	Family: 2 adults in 30's/40's & 1 child	1,250,000 – 1,499,999	Employed	2000	EAHP & ASHP a-a	1 electric	Hourly rate

(continued on next page)

Table A.1 (*continued*)

Respondents (fictitious names)	Household composition	Household's total yearly income, SEK[a] (before tax reduction)	Occupation status	House's year of construction	Heat pump type[b]	Number of cars with different fuels	Electricity contract[c]
Karl	Couple: 2 adults in 60's	1,500,000 and higher	Retired & Entrepreneur	1981	GSHP	1 electric & 1 fossil	Hourly rate
Fredrik	Family: 2 adults in 30's & 1 child	1,000,000 – 1,249,999	Employed	1960 (renovated 2018)	ASHP a-w	2 electrics	Hourly rate
Karin & Filip	Couple: 2 adults in 50's/60's	1,250,000 – 1,499,999	Employed	2000	GSHP	2 electrics	Hourly rate
Erik	Family: 2 adults in 40's & 2 teenagers	750,000–999,999	Employed	2004	EAHP	1 electric & 2 fossils	Fixed rate
Amanda	Family: 2 adults in 40's/50's & 3 teenagers	1,000,000 – 1,249,999	Employed	1940/2008	EAHP & ASHP a-a	1 electric[d] & 1 fossil	Hourly rate
Anna & Sven	Family: 2 adults in 40's & 2 children	1,500,000 and higher	Employed	2015	GSHP	1 electric & 1 plug-in hybrid	Monthly variable rate
Rune	Single person: 1 adult in 60's	750,000–999,999	Retired	1932	GSHP	1 electric[d] & 2 fossils	Hourly rate
Stefan	Family: 2 adults in 30's & 1 child	750,000–999,999	Employed & Parental leave	2022	EAHP	1 electric[d]	Hourly rate
Lars	Couple: 2 adults in 40's/60's	1,000,000 – 1,249,999	Employed	1976	GSHP	1 electric & 1 fossil	Monthly variable rate
Emilia & Johan	Couple: 2 adults in 50's	500,000–749,999	Employed	1875	GSHP	1 electric & 1 fossil	Hourly rate
Joel	Family: 1 adult in 40's & 3 children	500,000–749,999	Employed	2020	GSHP	1 electric	Fixed rate
Samuel	Family: 2 adults in 50's & 2 teenagers	1,500,000 and higher	Employed	1947/2008	GSHP	1 electric & 1 fossil	Hourly rate
Olle & Christine	Family: 2 adults in 40's & 3 children	750,000–999,999	Employed	2018	EAHP	1 electric & 1 fossil	Hourly rate
Tore	Family: 2 adults in 50's/60's & 2 young adult children	500,000–749,999	Employed	2017	GSHP & ASHP a-a	2 electrics	Monthly variable rate

a. Exchange rate: 1 EUR = 11.20 SEK.
b. GSHP = Ground source heat pump, EAHP = Exhaust air heat pump, ASHP a-w or a-a = Air source heat pump with air-to-water system or air-to-air system.
c. Hourly rate means that the household is charged by the hour according to spot prices per kilowatt hour. Monthly variable rate means that the household is charged according to the average electricity price per kilowatt hour during a period of time, typically a month. Fixed rate means that households pay the same price per kilowatt hour each month for the length of the contract regardless of variability in electricity prices.
d. Leased electric vehicle.

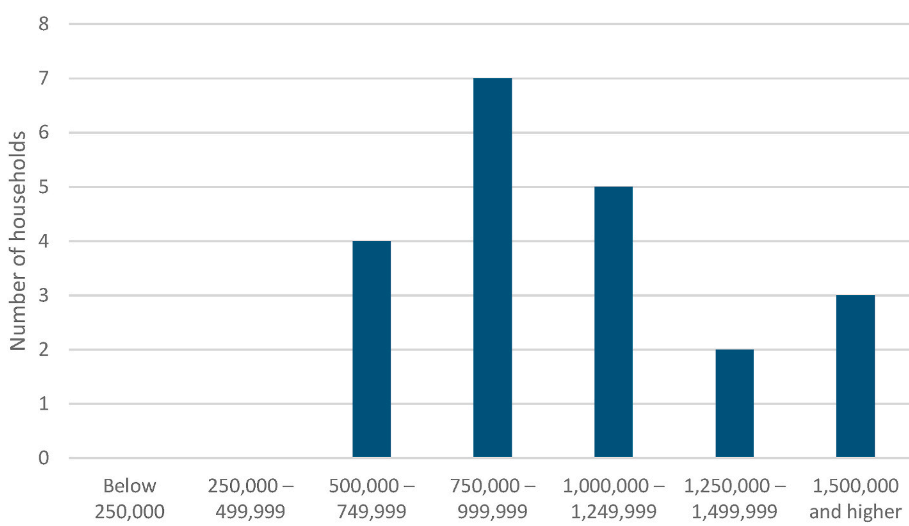

Fig. A.3. Distribution of total yearly incomes of the participating households, SEK (before tax reduction; exchange rate: 1 EUR = 11.20 SEK).

Data availability

The authors do not have permission to share data.

References

Ambrose, A., Davies, K., Shaw, B., Shahzad, S., Jiglau, G., Vornicu, A., Sinea, A., Lobont, D., Palm, J., von Platten, J., Krishna Ranjan, R., Pelsmakers, S., Kilpeläinen, S., Castano De la Rosa, R., Aho, H., 2023. Looking back to move forwards: a social and cultural history of home heating (JUSTHEAT): interim findings from the first round of case studies. https://doi.org/10.7190/cresr.2023.8293971428.

Andolfi, L., Marxen, H., Frank, M., 2024. Are you flexible enough? The impact of energy literacy and environmental values on flexibility provision. In: International Conference on the European Energy Market. EEM. https://doi.org/10.1109/EEM60825.2024.10608859.

Barr, J., Topel, M., 2022. In: Långsiktiga Scenarier För Introduktion Av Elfordon (Rapport 2022:899). Energiforsk.

Björner Brauer, H., Hasselqvist, H., Håkansson, M., Willermark, S., Hiller, C., 2024. Reconfiguring practices in times of energy crisis – a case study of Swedish households. Energy Res. Social Sci. 114, 103578. https://doi.org/10.1016/j.erss.2024.103578.
Björner Brauer, H., Håkansson, M., Willis, M., 2023. The ghost in the heat pump: examining social flexibility potential in thermal comfort practices through an experiment of remote-controlled heating in detached houses, in: European energy network. In: Proceedings of the 2023 BEHAVE Conference. the 7th European Conference on Behaviour Change for Energy Efficiency. Maastricht, Netherlands.
Blue, S., Shove, E., Forman, P., 2020. Conceptualising flexibility: challenging representations of time and society in the energy sector. Time Soc. 29, 923–944. https://doi.org/10.1177/0961463X20905479.
Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3, 77–101. https://doi.org/10.1191/1478088706qp063oa.
Bryman, A., 2016. Social Research Methods. Oxford University Press.
Cahill, J., Hoolohan, C., Browne, A.L., 2024. Social practice theory and household water demand: a review of literature and research evidence. Wiley Interdiscip. Rev.: Water 11. https://doi.org/10.1002/wat2.1719.
Cahill, J., Hoolohan, C., Lawson, R., Browne, A.L., 2022. COVID-19 and water demand: a review of literature and research evidence. Wiley Interdiscip. Rev.: Water 9. https://doi.org/10.1002/wat2.1570.
Chen, H., Ruud, S., Markusson, C., 2024a. Energy flexibility using thermal mass for Swedish single-family houses. E3S Web Conf. 562. https://doi.org/10.1051/e3sconf/202456204003.
Chen, W.A., Chen, C.F., Tomasik, S., 2024b. Investigating intentions and barriers in adopting decentralized home energy management systems: a justice dimension of demand flexibility. Energy Build. 318. https://doi.org/10.1016/j.enbuild.2024.114458.
do Carmo, C.M.R., Christensen, T.H., 2016. Cluster analysis of residential heat load profiles and the role of technical and household characteristics. Energy Build. 125, 171–180. https://doi.org/10.1016/j.enbuild.2016.04.079.
EC, 2023. Commission Sets out Actions to Accelerate the roll-out of Electricity Grids. European Commission.
Ei, 2020. Kapacitetsutmaningen i Elnäten (Ei R2020:06). Swedish Energy Markets Inspectorate.
Ei, 2022. Effektavgift. Swedish Energy Markets Inspectorate. https://ei.se/konsument/el/elnatsavgiften-och-elnatsreglering/effektavgift-effekttariff. (Accessed 18 March 2025).
El Gohary, F., Nordin, M., Juslin, P., Bartusch, C., 2022. Evaluating user understanding and exposure effects of demand-based tariffs. Renew. Sustain. Energy Rev. 155. https://doi.org/10.1016/j.rser.2021.111956.
Eurelectric, 2021. The Missing Piece. Powering the Energy Transition with Efficient Network Tariffs.
Gorenstein Dedecca, J., Ansarin, M., Bene, C., van Delzen, T., van Nuffel, L., Jagtenberg, H., 2025. Increasing Flexibility in the EU Energy System - Technologies and Policies to Enable the Integration of Renewable Electricity Sources. Publication for the Committee on Industry, Research and Energy, Policy Department for Transformation, Innovation and Health. European Parliament, Luxembourg.
Government Offices of Sweden, 2022. National Electrification Strategy – a Secure, Competitive and Sustainable Electricity Supply for a Historic Climate Transition. A Summary, Article No: I2022.04. Ministry of Infrastructure. Government Offices.
Gram-Hanssen, K., 2010. Introducing and developing practice theory: towards a better understanding of household energy consumption. In: Karlsson, K., Ellegård, K. (Eds.), Linköping Electronic Conference Proceedings, Campus Norrköping, pp. 45–58. Sweden.
Gram-Hanssen, K., 2024. Beyond energy justice: ethics of care as a new approach in the energy system. Energy Res. Social Sci. 111. https://doi.org/10.1016/j.erss.2024.103470.
Gram-Hanssen, K., Christensen, T.H., Madsen, L.V., do Carmo, C., 2020. Sequence of practices in personal and societal rhythms – showering as a case. Time Soc. 29, 256–281. https://doi.org/10.1177/0961463X18820749.
Gram-Hanssen, K., Hanssen, A.R., Madsen, L.V., Nielsen, R.S., 2025. The crisis that normalised time-shifting: energy flexibility, price awareness and care during the energy crisis in Denmark. Energy Effic. 18. https://doi.org/10.1007/s12053-025-10327-z.
Gram-Hanssen, K., Madsen, L.V., Aagaard, L.K., Nielsen, R.S., 2024. Heating practices during the energy crisis of 2022: the role of energy vulnerability and environmental concern. Sustain. Sci. Pract. Pol. 20. https://doi.org/10.1080/15487733.2024.2420413.
Hansen, A.R., Aagaard, L.K., 2025. Uncovering energy flexibility of everyday rhythms and routines in households with real-time electricity pricing. Energy Effic. 18. https://doi.org/10.1007/s12053-024-10291-0.
Hargreavesn, T., Nye, M., Burgess, J., 2010. Making energy visible: a qualitative field study of how householders interact with feedback from smart energy monitors. Energy Policy 38, 6111–6119. https://doi.org/10.1016/j.enpol.2010.05.068.
Henriksen, I.M., Strömberg, H., Branlat, J., Diamond, L., Garzon, G., Kuch, D., Yilmaz, S., Motnikar, L., 2025. The role of gender, age, and income in demand-side management acceptance: a literature review. Energy Effic. 18. https://doi.org/10.1007/s12053-025-10304-6.
Henriksen, I.M., Throndsen, W., Ryghaug, M., Skjølsvold, T.M., 2021. Electric vehicle charging and end-user motivation for flexibility: a case study from Norway. Energy Sustain. Soc. 11. https://doi.org/10.1186/s13705-021-00319-z.
Hofmann, M., Lindberg, K.B., 2024. Residential demand response and dynamic electricity contracts with hourly prices: a study of Norwegian households during the 2021/22 energy crisis. Smart Energy 13. https://doi.org/10.1016/j.segy.2023.100126.
IEA, 2023a. Global Heat Pump Sales Continue double-digit Growth. International Energy Agency. https://www.iea.org/commentaries/global-heat-pump-sales-continue-double-digit-growthLicence:CCBY4.0. (Accessed 8 December 2025).
IEA, 2023b. Net Zero Roadmap. A Global Pathway to Keep the 1.5 °C Goal in Reach. 2023 Update. International Energy Agency.
Jalas, M., Rinkinen, J., Silvast, A., 2016. The rhythms of infrastructure. Anthropol. Today 32, 17–20. https://doi.org/10.1111/1467-8322.12267.
Kaviani, F., Dahlgren, K., Koppel, S., Strengers, Y., Martin, R., Korsmeyer, H., Pink, S., 2025. "We'd rather have a clean planet than anything else": household values and automated future electric vehicle charging. Energy Res. Social Sci. 121, 103965. https://doi.org/10.1016/j.erss.2025.103965.
Laitinen, S.E., Syrjälä, H., Kylkilahti, E., Kääntä, L., 2025. Materials changing the performance of the household energy consumption practices. J. Consum. Cult. https://doi.org/10.1177/14695405251321405.
Li, R., Satchwell, A.J., Finn, D., Christensen, T.H., Kummert, M., Le Dréau, J., Lopes, R. A., Madsen, H., Salom, J., Henze, G., Wittchen, K., 2022. Ten questions concerning energy flexibility in buildings. Build. Environ. 223, 109461. https://doi.org/10.1016/j.buildenv.2022.109461.
Lindahl, M., Vinther Pedersen, S., Meesenburg, W., Spreitzhofer, J., Wernhart, M., Rieberer, R., Mascherbauer, P., Ortmann, P., Bakker, M., 2023. Task 4 Report: Flexibility Assessment and Analyses of Different Options (Report in IEA Heat Pumping Technologies Annex 57 "Flexibility by Implementation of Heat Pumps in multi-vector Energy Systems and Thermal Networks").
Lo Piano, S., Smith, S.T., 2022. Energy demand and its temporal flexibility: approaches, criticalities and ways forward. Renew. Sustain. Energy Rev. 160. https://doi.org/10.1016/j.rser.2022.112249.
Luo, M., Wang, Z., Brager, G., Cao, B., Zhu, Y., 2018. Indoor climate experience, migration, and thermal comfort expectation in buildings. Build. Environ. 141, 262–272. https://doi.org/10.1016/j.buildenv.2018.05.047.
Maller, C., Strengers, Y., 2013. The global migration of everyday life: investigating the practice memories of Australian migrants. Geoforum 44, 243–252. https://doi.org/10.1016/j.geoforum.2012.09.002.
Marxen, H., Ansarin, M., Chemudupaty, R., Fridgen, G., 2023. Empirical evaluation of behavioral interventions to enhance flexibility provision in smart charging. Transport. Res. Transport Environ. 123. https://doi.org/10.1016/j.trd.2023.103897.
Matschoss, K., Laakso, S., Rinkinen, J., 2025. Disruptions and energy demand: how Finnish households responded to the energy crisis of 2022. Energy Res. Social Sci. 121. https://doi.org/10.1016/j.erss.2025.103977.
Ministry of Climate and Enterprise, 2023. Frågor Och Svar Om Beslutet Om Hur Klimatbonusen Ska Avvecklas. Government Offices of Sweden. https://www.regeringen.se/artiklar/2022/11/fragor-och-svar-om-avskaffad-klimatbonus/. (Accessed 1 December 2025).
Muttaqee, M., Stelmach, G., Zanocco, C., Flora, J., Rajagopal, R., Boudet, H.S., 2024. Time of use pricing and likelihood of shifting energy activities, strategies, and timing. Energy Policy 187. https://doi.org/10.1016/j.enpol.2024.114019.
Muzammal Islam, M., Yu, T., Giannoccaro, G., Mi, Y., La Scala, M., Rajabi Nasab, M., Wang, J., 2024. Improving reliability and stability of the power systems: a comprehensive review on the role of energy storage systems to enhance flexibility. IEEE Access 12, 152738–152765. https://doi.org/10.1109/ACCESS.2024.3476959.
Nalini Ramakrishna, S.K., Björner Brauer, H., Thiringer, T., Håkansson, M., 2024. Social and technical potential of single family houses in increasing the resilience of the power grid during severe disturbances. Energy Convers. Manag. 321. https://doi.org/10.1016/j.enconman.2024.119077.
Nambiar, C., Schiavon, S., Brager, G., Rosenberg, S., 2025. Assessing thermal comfort and participation in residential demand flexibility programs. Energy Build. 328. https://doi.org/10.1016/j.enbuild.2024.115153.
Nicholls, L., Strengers, Y., 2015. Peak demand and the 'family peak' period in Australia: understanding practice (in)flexibility in households with children. Energy Res. Social Sci. 9, 116–124. https://doi.org/10.1016/j.erss.2015.08.018.
Nilsson, A., Bartusch, C., 2024. Empowered or enchained? Exploring consumer perspectives on direct load control. Energy Policy 192. https://doi.org/10.1016/j.enpol.2024.114248.
Onuki, Y., Otaki, Y., 2025. Managing peak water demand behavior through dynamic tariffs. J. Water Resour. Plann. Manag. 151. https://doi.org/10.1061/JWRMD5.WRENG-6738.
Ozaki, R., 2018. Follow the price signal: people's willingness to shift household practices in a dynamic time-of-use tariff trial in the United Kingdom. Energy Res. Social Sci. 46, 10–18. https://doi.org/10.1016/j.erss.2018.06.008.
Papias, I., Michalakopoulos, V., Sarmas, E., Marinakis, V., Antonesi, G., Cioara, T., Anghel, I., 2025. A data-driven framework for estimating residential energy flexibility for aggregated demand-side management. Sustain. Energy Grid. Netw. 43, 101783. https://doi.org/10.1016/j.segan.2025.101783.
Parrish, B., Heptonstall, P., Gross, R., Sovacool, B.K., 2020. A systematic review of motivations, enablers and barriers for consumer engagement with residential demand response. Energy Policy 138. https://doi.org/10.1016/j.enpol.2019.111221.
Pelka, S., Preuß, S., Stute, J., Chappin, E., de Vries, L., 2024. One service fits all? Insights on demand response dilemmas of differently equipped households in Germany. Energy Res. Social Sci. 112. https://doi.org/10.1016/j.erss.2024.103517.
Pink, S., Korsmeyer, H., Dahlgren, K., Strengers, Y., 2024. Automation in electric vehicle futures. Mobilities. https://doi.org/10.1080/17450101.2024.2325385.
Pitkänen, O., Skjølsvold, T.M., 2024. Shifting patterns – the patterned enactments of flexible electricity consumption by Norwegian households. Energy Res. Social Sci. 115. https://doi.org/10.1016/j.erss.2024.103639.
Power Circle, 2025. Elbilsåret 2024.

Reckwitz, A., 2002. Toward a theory of social practices: a development in culturalist theorizing. Eur. J. Soc. Theor 5, 243–263.

Rustamovich Esanov, A., Gyoon Lim, C., 2025. Enhancing grid stability and renewable energy integration with reinforcement learning for optimized demand response. Energy Explor. Exploit. https://doi.org/10.1177/01445987251360274.

Santillán, O.S., Cedano, K.G., 2023. Energy literacy: a systematic review of the scientific literature. Energies 16. https://doi.org/10.3390/en16217235.

Schatzki, T.R., 1996. Social Practices: a Wittgensteinian Approach to Human Activity and the Social. Cambridge University Press, Cambridge, p. 1996.

SFS, 2017. 1334, Förordning Om klimatbonusbilar/Ordinance on Climate Bonus Cars. Ministry of Climate and Enterprise, Stockholm.

Shen, B., Kahrl, F., Satchwell, A.J., 2021. Facilitating power grid decarbonization with distributed energy resources: lessons from the United States. Annu. Rev. Environ. Resour. 46, 349–375. https://doi.org/10.1146/annurev-environ-111320-071618.

Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. J. Consum. Pol. 26, 395–418. https://doi.org/10.1023/A:1026362829781.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and How It Changes. SAGE Publications, London. https://doi.org/10.4135/9781446250655.

Shove, E., Walker, G., 2014. What is energy for? Social practice and energy demand. Theor. Cult. Soc. 31, 41–58. https://doi.org/10.1177/0263276414536746.

Sperber, E., Schimeczek, C., Frey, U., Cao, K.K., Bertsch, V., 2025. Aligning heat pump operation with market signals: a win-win scenario for the electricity market and its actors? Energy Rep. 13, 491–513. https://doi.org/10.1016/j.egyr.2024.12.028.

Spurling, N., 2021. Matters of time: materiality and the changing temporal organisation of everyday energy consumption. J. Consum. Cult. 21, 146–163. https://doi.org/10.1177/1469540518773818.

Stange, T.R., Ryspaeva, I., Kurt, M., Muller, P., 2025. Process model for aggregation of decentralized flexibility pools in Germany considering technical and market restrictions. In: International Conference on the European Energy Market. EEM. https://doi.org/10.1109/EEM64765.2025.11050167.

Statistics Sweden, 2023. Tredubbling av elbilar på två år. https://www.scb.se/hitta-statistik/redaktionellt/tredubbling-av-elbilar-pa-tva-ar2/. (Accessed 18 March 2024).

Statistics Sweden, 2024. Hushållens boende 2023 (Households' housing 2023). https://www.scb.se/hitta-statistik/statistik-efter-amne/boende-bebyggelse-och-mark/bostader-och-boende/hushallens-boende/pong/statistiknyhet/hushallens-boende-2023/. (Accessed 15 April 2025).

Statistics Sweden, 2025a. Distribution of electricity contracts by bidding zone and contract type. Month 2013M04 - 2025M02. https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_EN_EN0301_EN0301A/SSDManadElAvtalstyp/. (Accessed 21 February 2025).

Statistics Sweden, 2025b. Income and Tax Statistics. (Accessed 19 February 2025).

Stelmach, G., Zanocco, C., Flora, J., Rajagopal, R., Boudet, H.S., 2020. Exploring household energy rules and activities during peak demand to better determine potential responsiveness to time-of-use pricing. Energy Policy 144. https://doi.org/10.1016/j.enpol.2020.111608.

Stikvoort, B., El Gohary, F., Nilsson, A., Bartusch, C., 2024. Serving two masters – how dual price signals can undermine demand flexibility. Energy Policy 185. https://doi.org/10.1016/j.enpol.2023.113918.

Strengers, Y., 2013a. Comfort expectations: the impact of demand-management strategies in Australia. In: Shove, E., Chappells, H., Lutzenhiser, L., Lorch, R. (Eds.), Comfort in a Lower Carbon Society. Routledge, pp. 77–87.

Strengers, Y., 2013b. Peak electricity demand and social practice theories: reframing the role of change agents in the energy sector, the global challenge of encouraging sustainable living: opportunities. Barr. Pol. Prac. 18–42. https://doi.org/10.4337/9781781003756.00010.

Strengers, Y., Maller, C., 2012. Materialising energy and water resources in everyday practices: insights for securing supply systems. Glob. Environ. Change 22, 754–763. https://doi.org/10.1016/j.gloenvcha.2012.04.004.

Swedish Energy Agency, 2024. Energistatistik för småhus (Energy statistics for one- and two dwelling buildings 2023). https://www.energimyndigheten.se/statistik/officiell-energistatistik/tillforsel-och-anvandning/energistatistik-for-smahus/. (Accessed 15 April 2025).

Swedish Tax Agency, n.d. Grön teknik. https://www.skatteverket.se/privat/fastigheterochbostad/gronteknik (accessed 30 November 2025).

Thompson, J., 2022. A guide to abductive thematic analysis. Qual. Rep. 27, 1410–1421. https://doi.org/10.46743/2160-3715/2022.5340.

Torriti, J., Ramírez-Mendiola, J.L., 2022. The price is not right! energy demand, time of use tariffs, values and social practices. Eceee Summer Study Proc. 75–84.

Transport Analysis, 2023. Vem väljer en elbil? De svenska hushållens val av elbilar och laddhybrider (Rapport 2023:2. www.trafa.se.

Transport Analysis, 2024. Elektrifierade Fordon i Sverige – En Analys Av Laddbara Fordon Över Tid Och Geografi (Rapport: 2024:10).

Transport Analysis, 2025a. Fordon i Län Och Kommuner 2024 (Vehicles in Counties and Municipalities 2024).

Transport Analysis, 2025b. New vehicle registrations. https://www.trafa.se/en/road-traffic/vehicle-statistics/.

Vaismoradi, M., Turunen, H., Bondas, T., 2013. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. Nurs. Health Sci. 15, 398–405. https://doi.org/10.1111/nhs.12048.

Vanhaverbeke, L., Verbist, D., Barrera, G., 2024. Consumer Monitor 2023. European Alternative Fuels Observatory. European aggregated report. European Commission.

Vilaseca, A.M., Crawley, J., Shipworth, M., Elwell, C., 2022. Living with demand response: insights from a field study of DSR using heat pumps. In: Eceee Summer Study Proceedings. Hyères, France.

Walker, G., 2014. The dynamics of energy demand: change, rhythm and synchronicity. Energy Res. Social Sci. 1, 49–55. https://doi.org/10.1016/j.erss.2014.03.012.

Wu, Z., Qi, M., Zhang, W., Zhang, X., Yang, Q., Zhao, W., Yang, B., Lyu, Z., Wang, F., Wang, Z., 2025. The electricity load prediction model for residential buildings: a critical review of output types, prediction methods and driving factors. Buildings 925. https://doi.org/10.3390/buildings15060925.

Zapieo, J.L., Menon, A.R., Hedin, B., 2024. 'That is what we can influence': exploring energy time-shifting using an always-on display in households with solar panels. In: Proceedings - 2024 10th International Conference on ICT for Sustainability. ICT4S 2024, pp. 324–334. https://doi.org/10.1109/ICT4S64576.2024.00040.